A. Nikitenko CERN and ITEP/Moscow

Triggering on SUSY H/A->2τ , τ -> hadrons

- **motivation for Tau trigger**

  physics simulation on H/A -> 2τ -> 2jet by
  R. Kinnunen, D. Denegri CMS Note 1999/037

- **L1 Tau trigger**

  Algorithm and ORCA code by S. Dasu

- **L2.0 Calorimeter Tau trigger**

  S. Eno, R. Kinnunen, A. Nikitenko

- **PossibleTau Trigger with Pixel Detector**

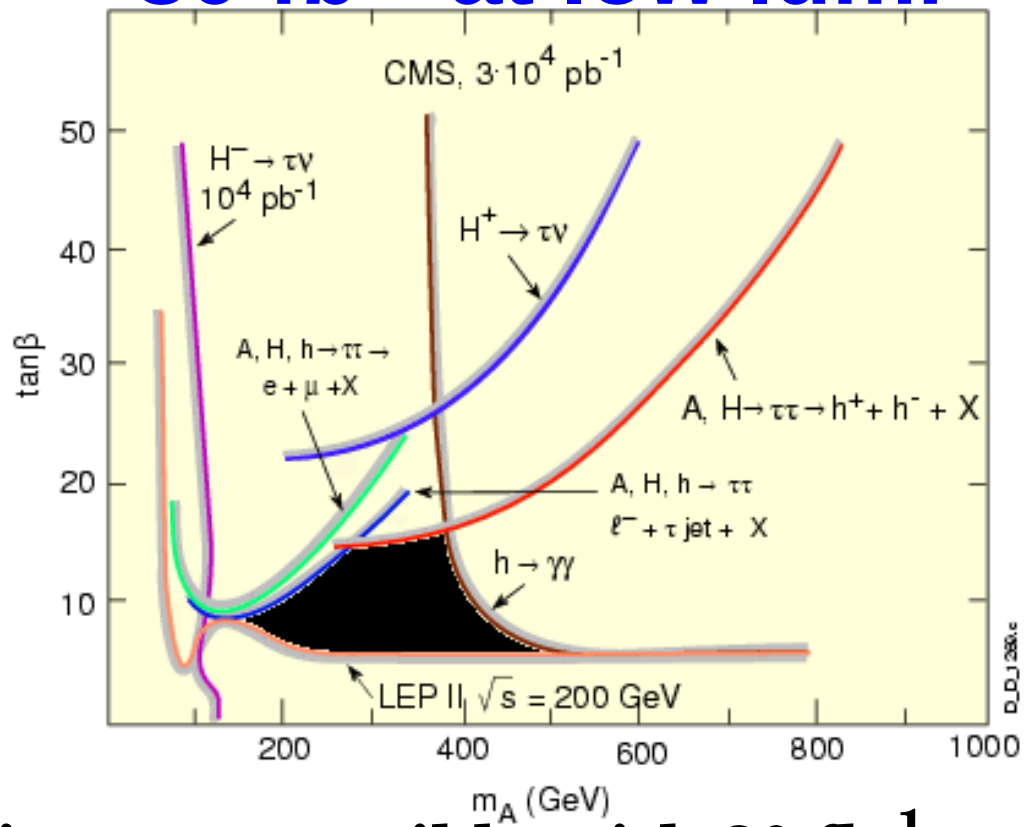
  track/vertex finding algo and ORCA code by D. Kotlinski

Why do we need H->2τ channels ?

A large region of MSSM parameters M_A , tan(β) can be explored already with low lumi data combining

e+μ, e/μ+jet, 2 jets final states

5 σ discovery with 30 fb^{-1} at low lumi



the black hole is not accessible with 30 fb^{-1}

Why do we need high lumi data for H->2τ

- to have an access to the black hole area of M_A- tanβ plane :

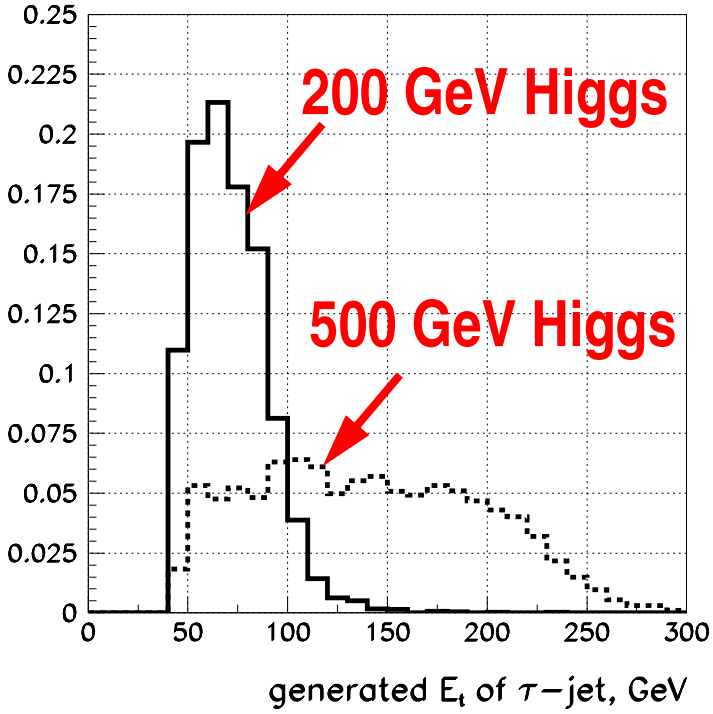
  $150 < M_A < 400$ GeV, tan$\beta < 10$

- to measure H/A Higgs mass and tanβ with as high as possible statistics

Why do we need Tau Trigger for H->2τ->2j

1 kHz rate thresholds at generator level : 1J > 165 GeV, 2J > 120 GeV

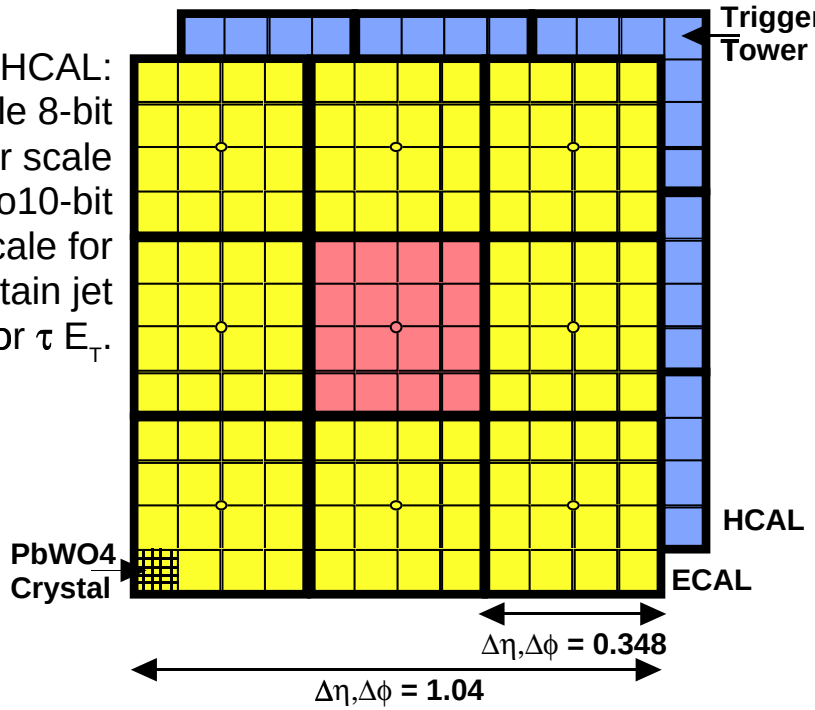
=> too high for τ-jets from the low mass Higgs of 200 - 300 GeV



L1 Tau trigger must enhance the efficiency for triggering on taus that produce low E_t jets

Updated Jet, τ Algorithms

Input from E/HCAL: Programmable 8-bit non-linear scale converted into10-bit linear scale for sums to obtain jet or τ E_T.



Active towers counted after a trigger tower level programmable threshold. τ-veto bit formed by requiring that there be no more than 2 active ECAL or HCAL towers in a 4 x 4 region.

Jet or τ E_T

- **12x12 trigger tower E_T sums sliding in 4x4 steps with central 4x4 > others**

τ algorithm (isolated narrow energy deposits)

- **Redefine Jet as τ if none of the 9 4x4 region τ-veto bits are on**

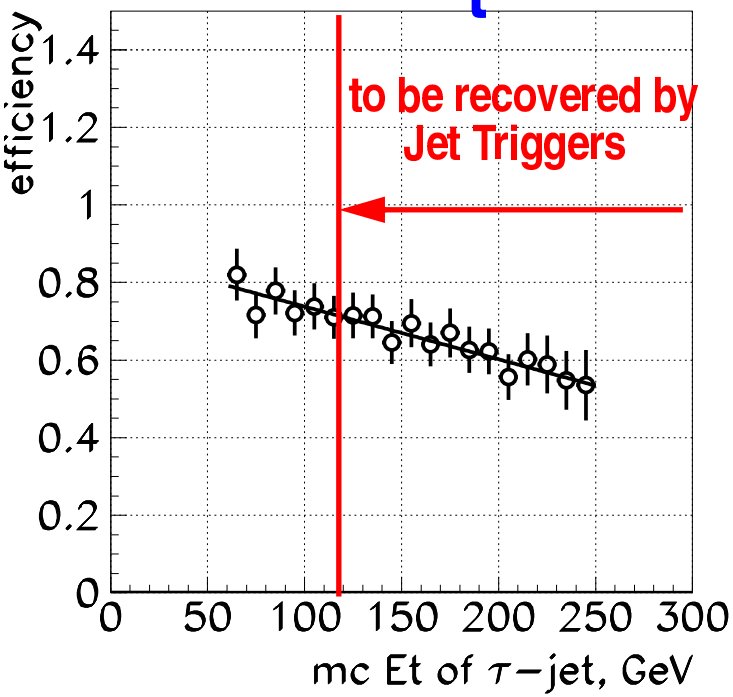
Output

- **Sorted top 4 jets & top 4 τ-jets & counts of jets above programmable thresholds**

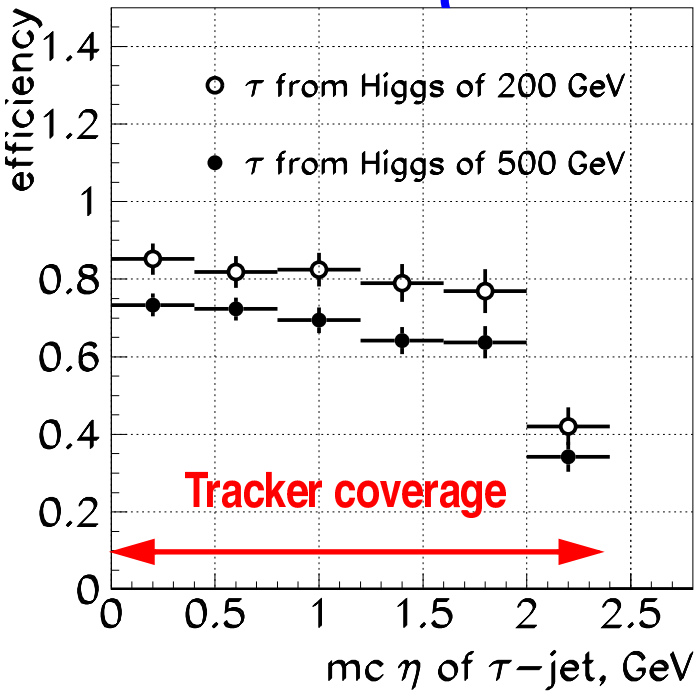
L1 Tau trigger

efficiency of τ-id in gg->bbA, A->2τ->h^+h^-+X

efficiency of τ-id v.s. $E_t^{\tau\text{-jet}}$



efficiency of τ-id v.s. $\eta^{\tau\text{-jet}}$



L1 Tau trigger

Efficiency for gg->bbA/H, A/H->2τ->h^++h^-+X

relative to "off-line" events: $E_t^{\tau\text{-jet}}$>60 GeV, $|\eta^{\tau\text{-jet}}|$ <2.4, 1 prong τ's

HIGGS MASS	OLD TRIGGER	NEW TAU	NEW TAU+JET
200 GEV	0.29	0.64	0.64 (0.65)
500 GEV	0.91	0.81	0.89 (0.95)
L1 RATE	5.5 KHZ	4.0 KHZ	4.8 (6.3) KHZ
	1j > 100 GeV	1τ > 80 GeV	1τ > 80 GeV
	2j > 60 GeV	2τ > 50 GeV	2τ > 50 GeV
	3j > 30 GeV		1 cj > 200(120) GeV
	4j > 20 GeV		2 cj > 100(80) GeV

A big improvement with the new trigger for the low mass Higgs

L1 Tau trigger

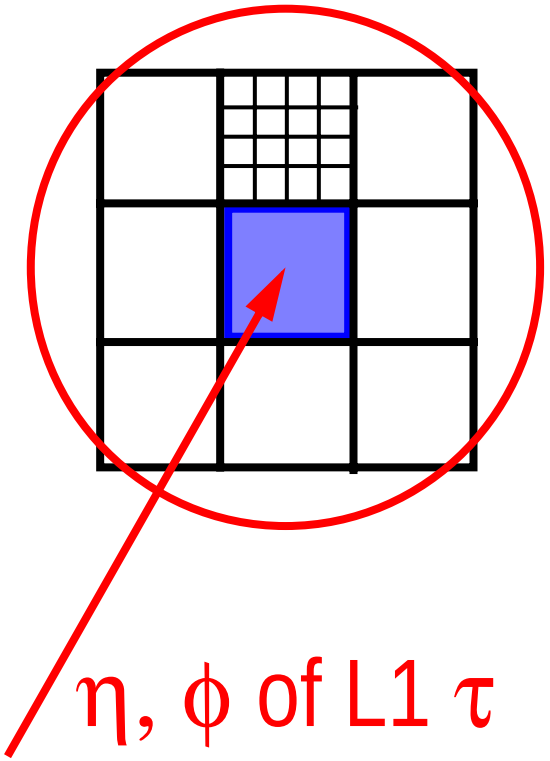
Purity of L1 Tau's in gg->bbA, A->2τ->h^+ + h^- + X events passed L1 and off line selections

Higgs mass	1-st L1 Tau Jet* is not a Tau	2-nd L1 Tau Jet is not a Tau
200 GeV	(1.6+-0.5) %	(14.3+-0.2) %
500 GeV	(1.3+- 0.3)%	(45.0+-0.2) %

L2.0 Tau trigger operates on 1-st L1 Tau Jet

* 1-st L1 Jet is a Jet with a highest E_T; Jets are ordered in E_T in the trigger object list

L2.0 Tau trigger



1. reconstruct a Jet*
2. calculate e.m. isolation :

$$P_{isol} = E_t^{ecal}(R < 0.4) - E_t^{ecal}(R < 0.13)$$

3. accept event if $P_{isol} < P_{cut}$

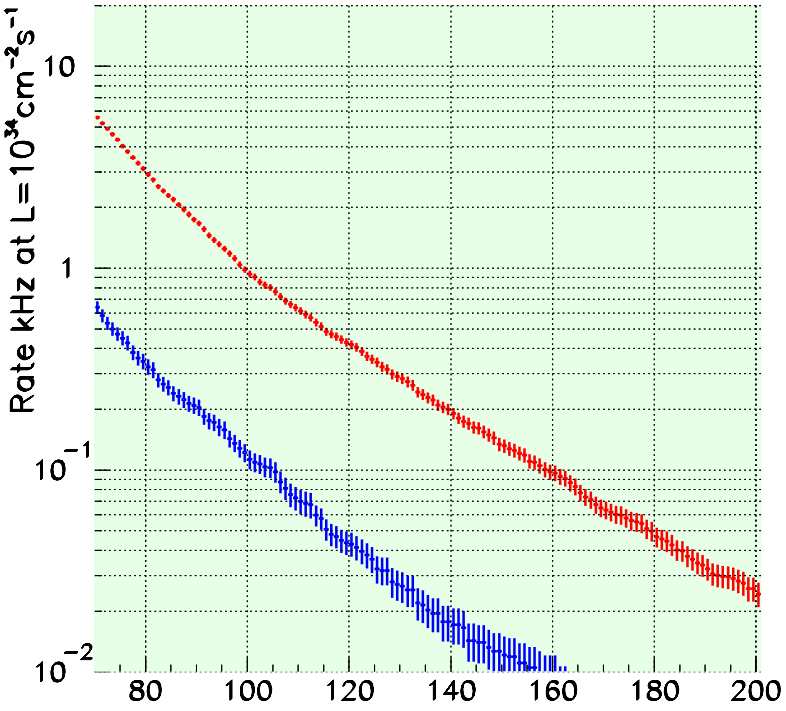
* At L2.0 Jet is reconstructed in the location of the L1 highest E_t Tau with an iterative cone of size 0.6 and ecal+hcal towers as an input

L1 and L2.0 Tau trigger rates

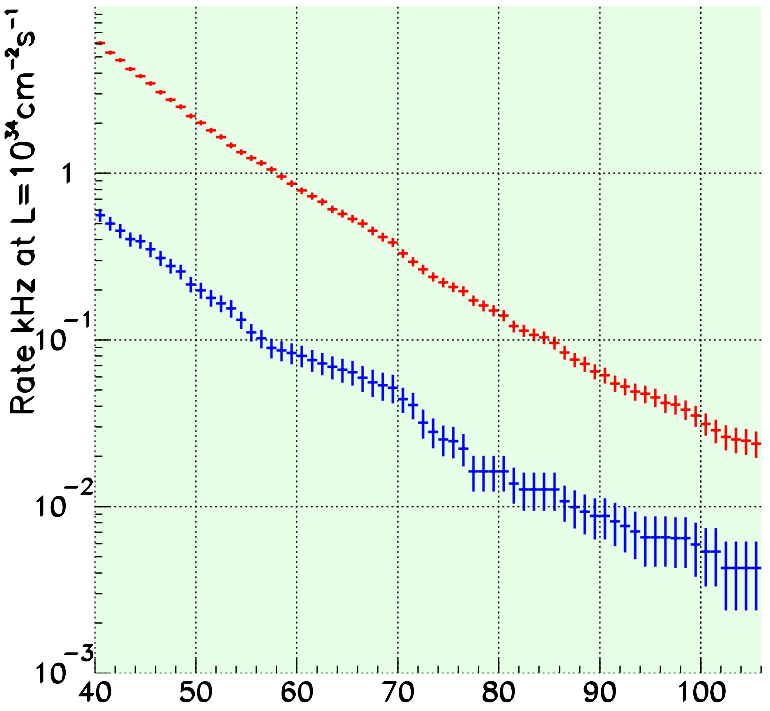
Single Jet rates

Double Jet rates

red - L1 Tau, blue - L2.0 Tau



E_t^{thr} (12x12), GeV



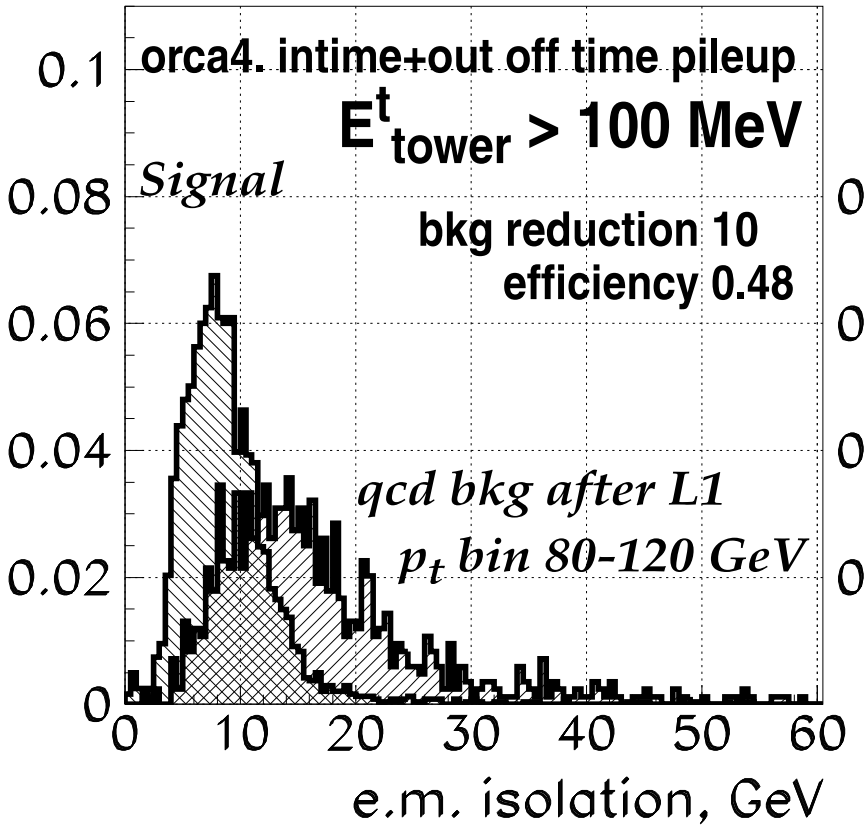
E_t^{thr} (12x12), GeV

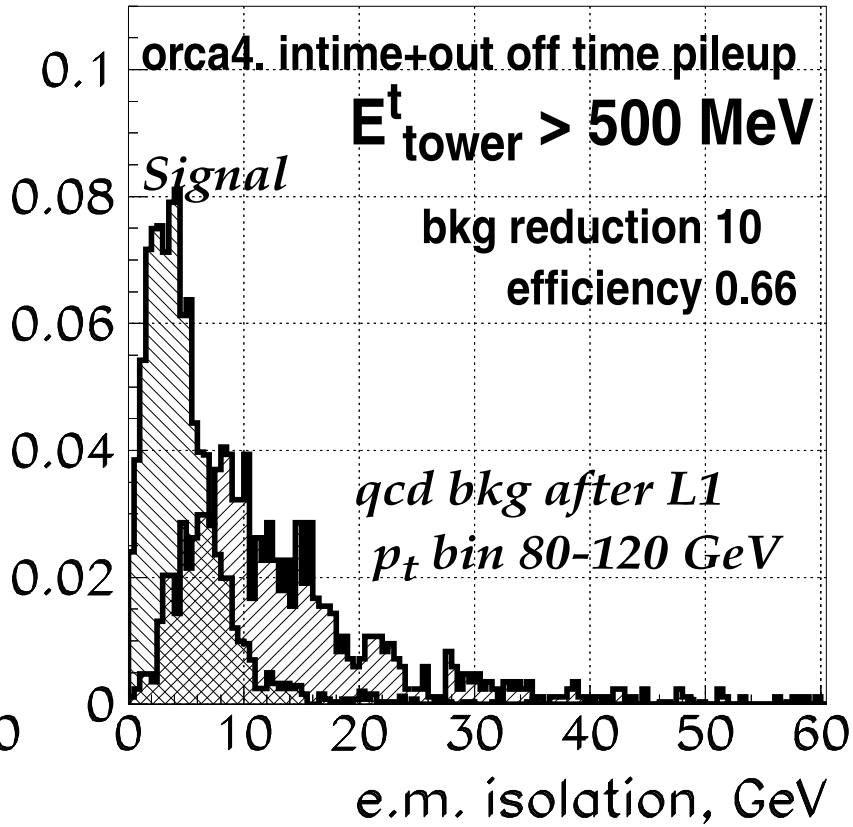
L2.0 Tau trigger

out off time pileup and e.m. isolation

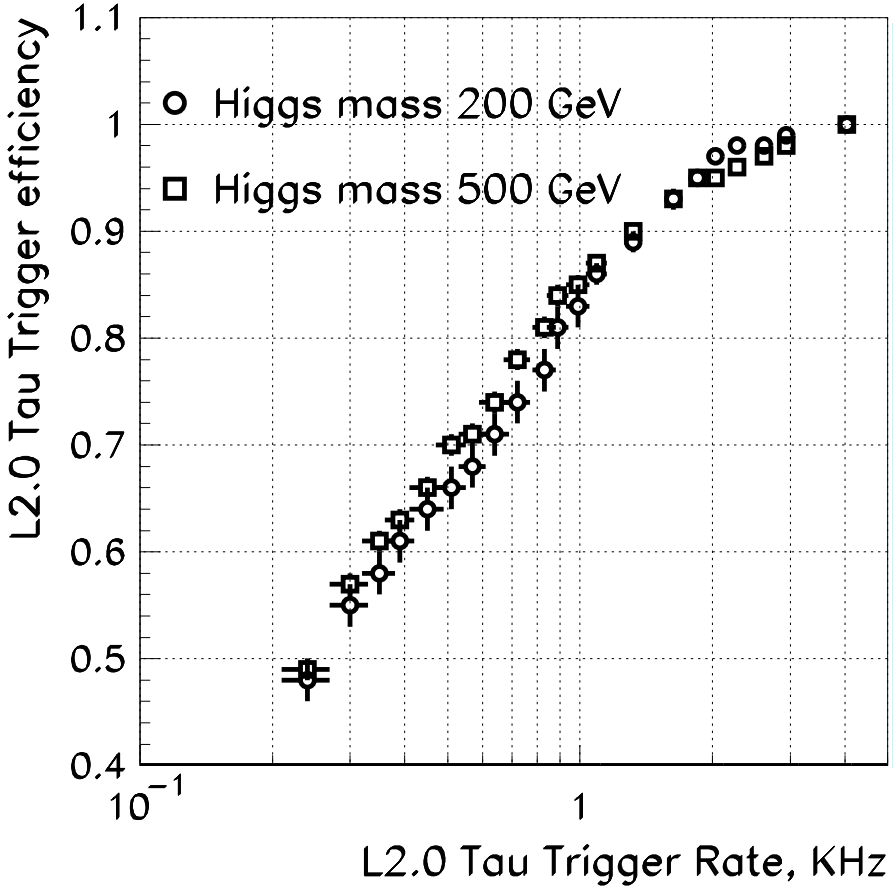
orca3 with in time pileup only
(cms in 2000/033) :

- L1 jet rate reduction - 10
- efficiency L2.0 for M_H=200 GeV - 0.65





L2.0 Tau Trigger efficiency v.s. reduction of L1 Tau Trigger rate



for gg->bbA, A->2τ->h^+h^-+X ev.
passed L1 triggers :

1τ > 80 GeV

2τ > 50 GeV

"off-line" selections :

$E_t^{\tau\text{-jet}}$ > 60 GeV

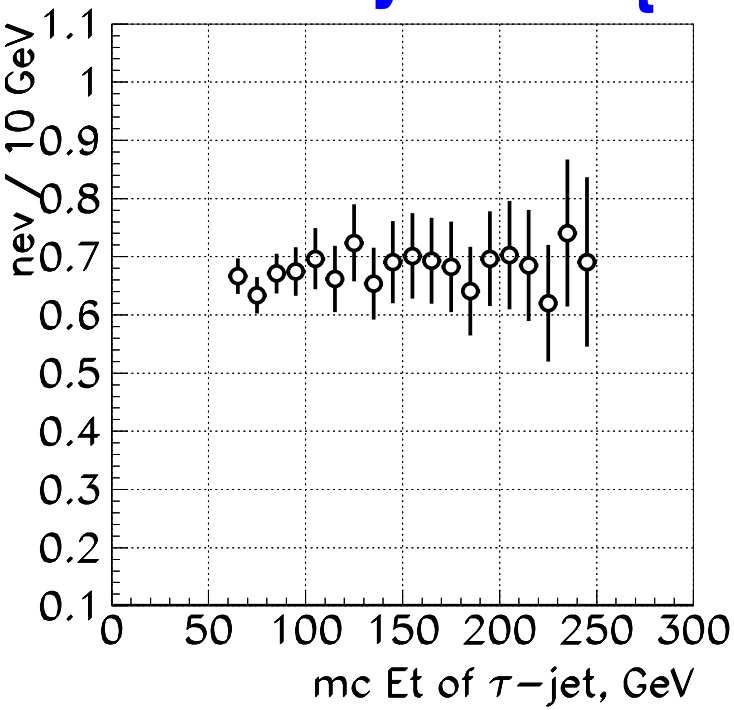
$|\eta^{\tau\text{-jet}}|$ > 2.4

1 prong τ-jets

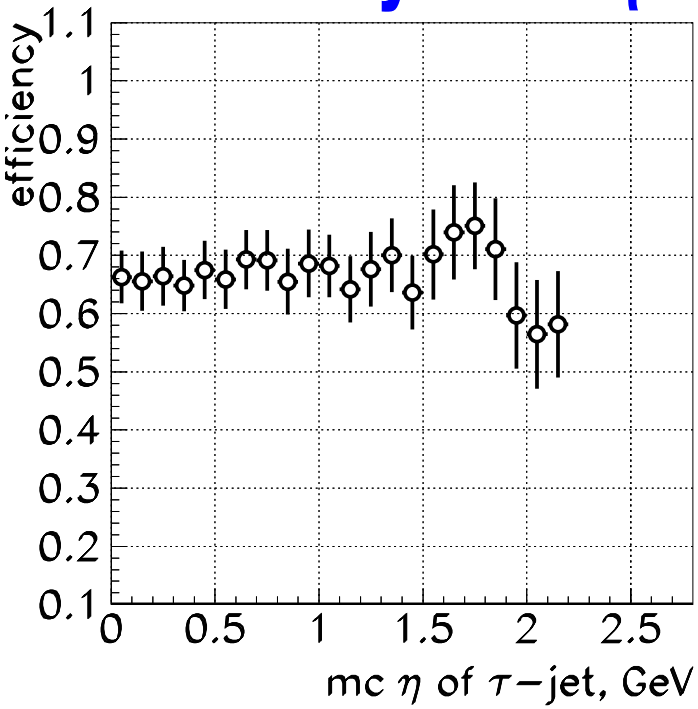
L2.0 Tau trigger

efficiency of L2.0 for τ's passed L1 Tau id

efficiency v.s. $E_t^{\tau\text{-jet}}$



efficiency v.s. $\eta^{\tau\text{-jet}}$



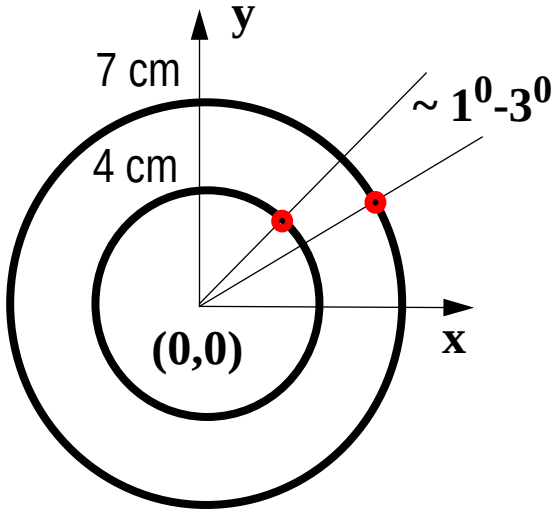
L1, L2.0 Calorimeter Tau Trigger studies are summarized in
CMS Note 2000/055
by S. Eno, S. Dasu, R. Kinnunen, A. Nikitenko, W. Smith

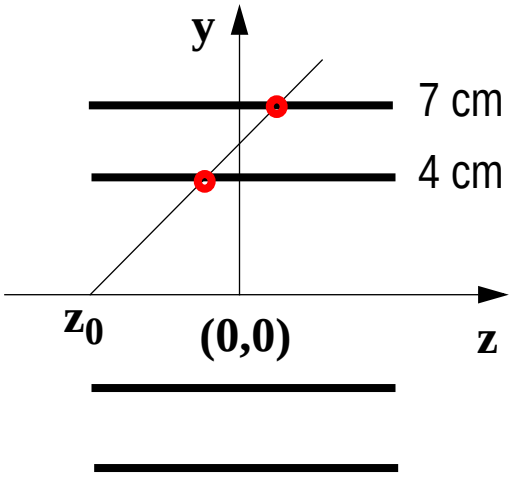
Tracker isolation of τ-jet candidates as a next step to reduce rate *following the off-line selection - 1 prong τ-jet*

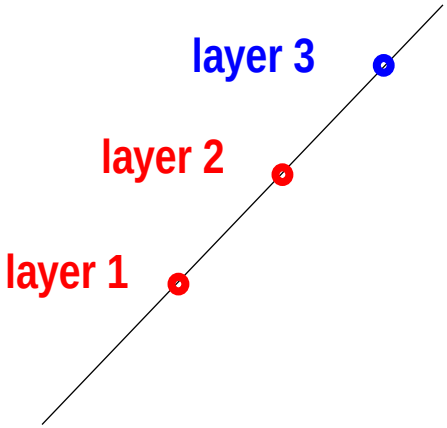
Track/vertex finding with Pixel Detector only (10 % of all tracker data) looks very promising

algorithm and ORCA code by D. Kotlinski PSI. CMS IN 2000/022

Pixel Track and Vertex Finder Algorithm.







1. ϕ matching of 2 hits

2. Z matching: $|Z_0| < 15$ cm

3. matching with 3-d hit

4. primary vertices (PV) with histogr. method

5. p_t and charge of the track with 3 points

6. find "signal" PV (criteria of N_{track} and Σp_t^{tr})

Pixel Track Finder. Performance I

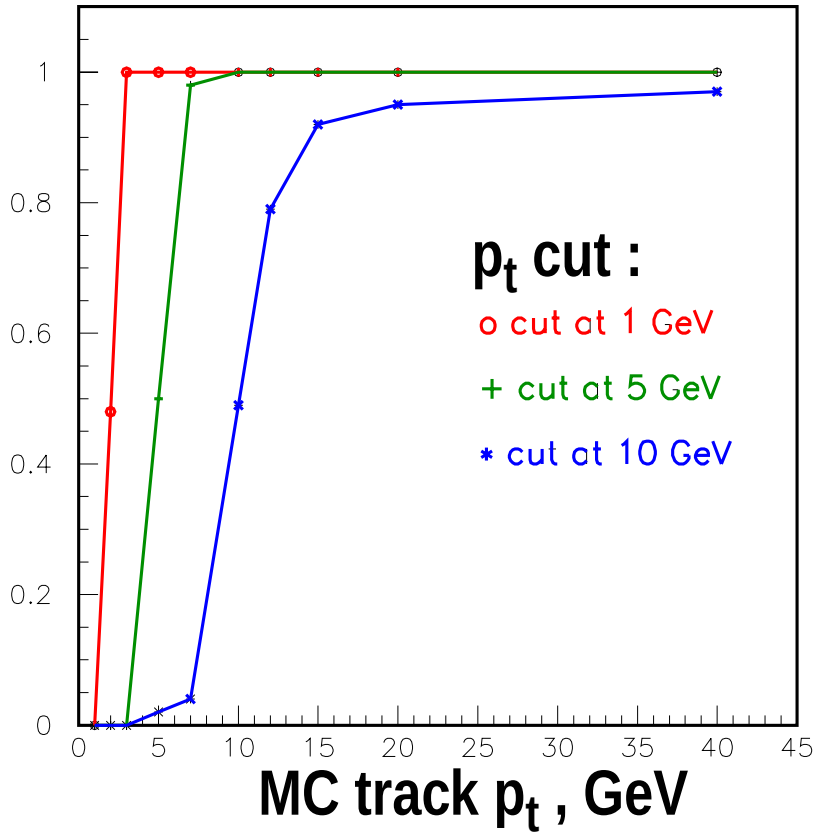
A. Track/Vertex finding efficiency
see next slides

B. Track momentum estimate
up to 20 GeV :
$\sigma(\Delta p_T)/p_T=(3.6+1.7\ p_T[\mathrm{GeV}])\ \%$

C. Track charge estimate
100% efficient up to 20 GeV
At 40 GeV - 2% error

D. Impact Parameter
poor resolution :
70 (125) μm at 10 (1) GeV

Efficiency of a cut on the track momentum measured with Pixel Detector only



Pixel Track Finder. Performance II

Track finding efficiency and ghost rates with 3 pixel layers at high luminosity

event type	efficiency		ghost rate	
	any p_t^{rec}	p_t^{rec}> 1 GeV	any p_t^{rec}	p_t^{rec}> 1 GeV
gg->bbA(500 GeV)->2τ->h^+ h^- X	0.96	0.93	0.09	0.04
QCD di-jets, E_t^{jet}> 60 GeV	0.94	0.93	0.10	0.05

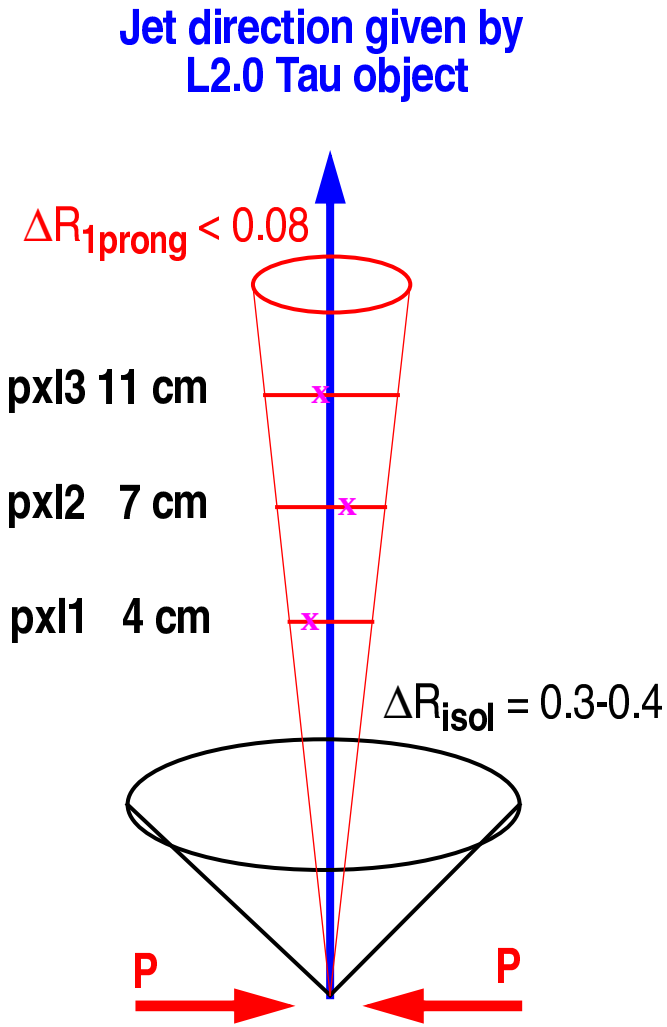
efficiency = N_{good} / N_{acc} , ghost rate = N_{ghost} / N_{reco}

good track - reco track associated with 3 hits of the same MC track of p_t> 1 GeV

accepted track - MC track of p_t > 1 GeV generated 3 hits in the pixel barrel

ghost track - a track with at least one hit came from a different MC track

Application I. Tau Trigger at Lvl -3.



Possible Lvl-3 τ-trigger

1. Tracks are reconstructed with 3 pixel layers only within a cone given by L2.0 Jet axis

2. Isolation criteria is applied in a big cone (0.3-0.4) relative to the tracks in a small cone (~0.1). p_t^{tr} > 1-2 GeV

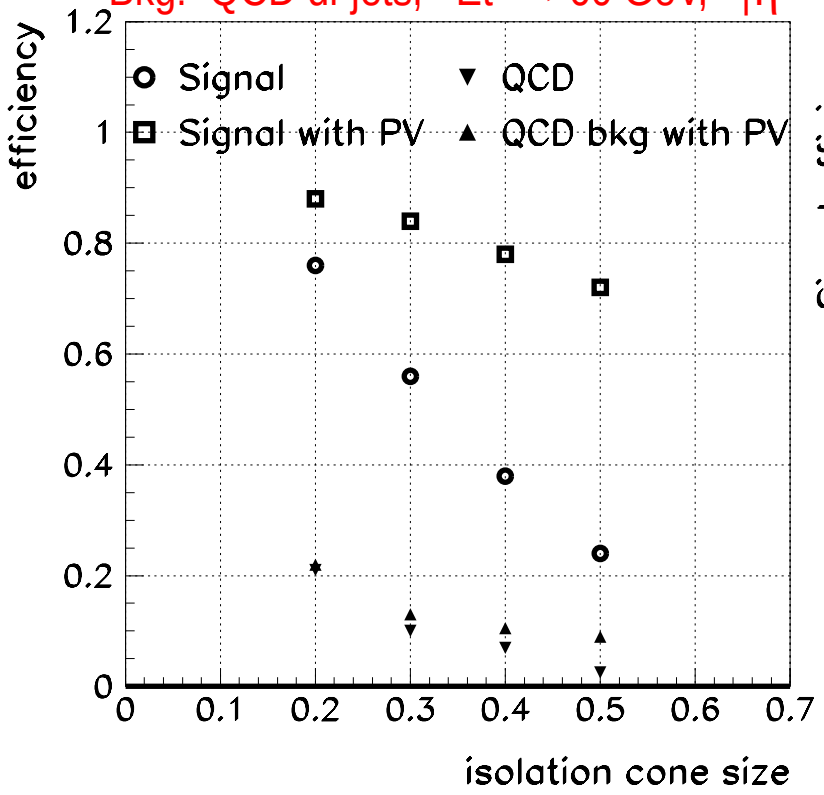
Application I. Tau Trigger at Lvl -3.

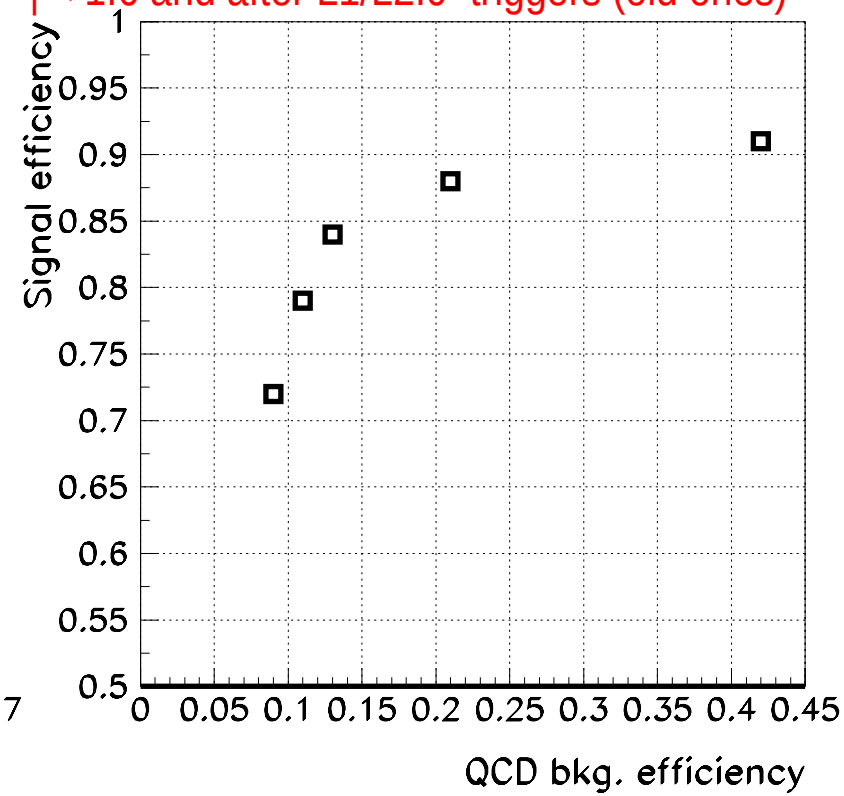
preliminary study (cms116+fort/C++ analysis) looks very promising.

L1/L2.0 calo preselection - A. Nikitenko. Pixel Track Finder - D. Kotlinski; high luminosity

Signal : gg->bbA(500 GeV), A->2τ->2jets, $Et^{\tau\text{-jet}}$ >60 GeV, $|\eta^{\tau\text{-jet}}| < 1.6$ and after L1/L2.0

Bkg: QCD di-jets, Et^{jet} >60 GeV, $|\eta^{jet}| < 1.6$ and after L1/L2.0 triggers (old ones)





results will be checked with updated L1/L2.0 Tau and September ORCA4 run data

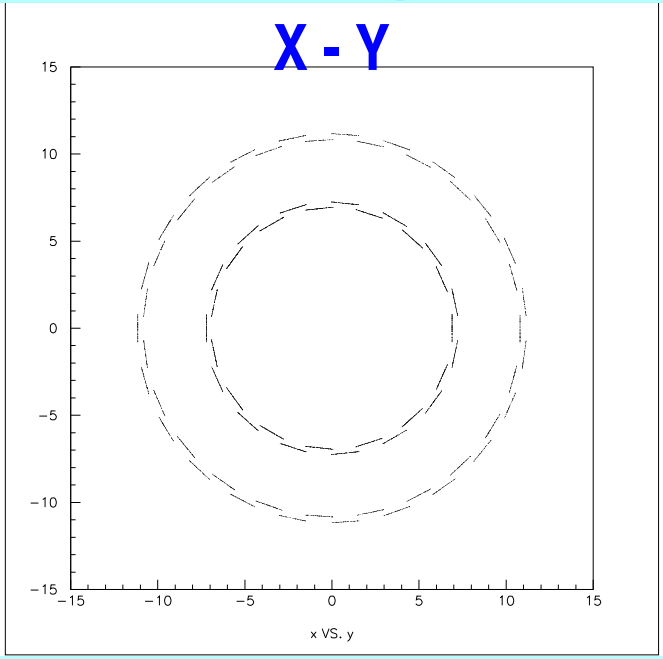
The way proposed by CMS SW people to start tracker trigger studies :

L1,L2.0 Tau filter -> User Collection -> deep copy -> add TkDigi

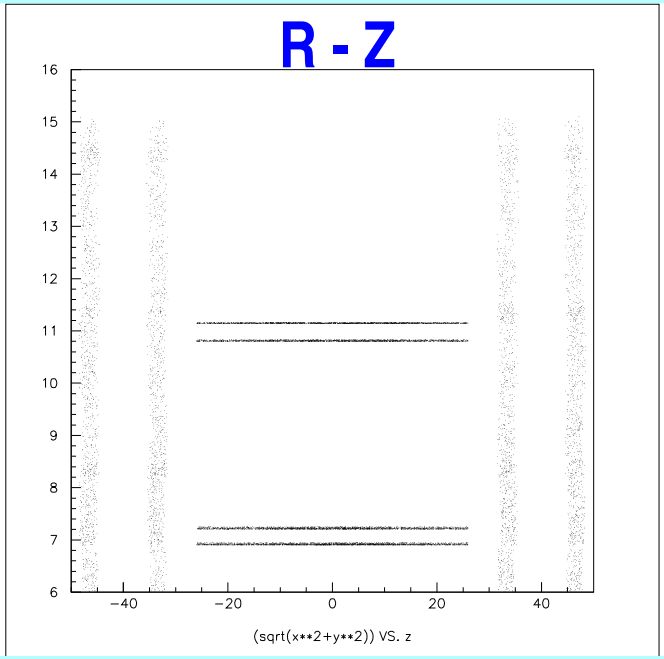
has been passed. Many thanks Vincenzo, Veronique, Stephan, Teddi

***Test*: Pixel Rhits for gg->bbH, H->2τ->2j events from jetmet UF (cms116)**
passed L1,L2 Tau filter
produced with a part of Danek PixelReconstruction code in orca430

X - Y



R - Z



cms120 events with 3 pixel layers are arriving